VARIATIONS

In

The Ossification Of The Human Skull

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Vol. I.

This investigation has been carried out in the Anatomical Department of the University of Edinburgh during the last eight months of the year 1900.

I made observations on 15 points of variation in a series of 613 crania, representative of civilised and exotic races.

Whilst making my observations on these points I noticed additional variations which had not previous-ly been described:-

(1) Meningeal grooves on the <u>external</u> surface of the skull.

(2) Median condylar foramen.

(3) Boat-shaped palate.

(4) Indications of the separation of the tabular portion of the occipital from the ex-occipitals in the <u>adult</u> skull.

(5) The skull of Kempff a German gave me the idea of the frontal grooves, but the priority of discovery and publication belong to Professor Dixon of Cardiff.

The variations found in the human skull are replete with interest, affording as they do in some instances remarkable conformity to structures which in lower forms of life are found to be normally present.

I have at every step availed myself of the information obtained from the study of Comparative Anatomy.

A general review of my investigation seems to point out that many of these variations are not so so characteristically "simian" as had hitherto been supposed.

The enquiry has resulted in a new--and I believe correct--explanation of the manner in which the cranial plates increase in area. My theory in addition explains the variations found in the pterion (including epipterics), in the bregma and on the inner wall of the orbit. Further it explains the significance of the sutural and fontanellar ossicles and gives an intelligent interpretation to the digitations and undulations which are so characteristic of the margins of the cranial plates.
It thus incidentally accounts for several variations that have not hitherto been satisfactorily explained. All this is additional evidence that my explanation of the ossification of the skull is the unfolding of a new truth.

I have determined the fact that wormians unite with one or other of the bones between which they are produced, both in infant and adult crania.
Hitherto I have had no time to make observations on embryo material. But it may legitimately be deducted from the unity of the process of ossification that wormians form and blend in a similar manner in fœtal skulls. Gray (p.166) figures but does not describe two wormians in the anterior fontanelle of

of a fœtal skull at birth. Everything augurs well that I can firmly establish my theory by further tera-tological research.

The accompanying photographs illustrate some of the more important variations described in the thesis. Pen-and-ink sketches are too apt to exaggerate the points they are intended to illustrate.

The observations have been taken and the thesis has been composed entirely by myself.

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Five years ago I first had the opportunity of appreci-ating Anatomy in its Anthropological bearings.
I then attended Professor Sir William Turner's Courses of Anatomy and Anthropology, and afterwards presented myself for these as my "special" subjects in the final examination in Pure Science.
I have made free use of the notes I took when I attended his lectures, and also of his well-known monograph on the "Challenger" crania.

I take this opportunity of expressing my most cordial thanks to Professor Sir William Turner for the unrestricted access that I enjoyed to his valua-ble collection of skulls and also for permission to photograph those that presented the most interesting

interesting variations.
I am also greatly indebted to him for the facilities that I had in making my observations, for numerous suggestions and references to literature.
In short I entirely attribute this thesis to his kind encouragement to enquiry.

WORMIAN or SUTURAL BONES.-

Bones irregular in shape and possessing denticulated margins are often found intercalated between the cranial plates. They have been variously named wormian, sutural, triquetral or supernumerary bones. They are most appropriately designated "Sutural" as their occurrence in a suture may be taken as a general characteristic feature of these bones.
They are also named after WORMIUS of Copenhagen who, it is supposed, was the first to describe these bones early in the eighteenth century. They resemble the bones between which they are placed in their membranous origin, their structure and their mode of articulation. Béclard states that they never appear before birth, but it is difficult to conceive how parturition could in any way change the course of the ossific process in the sutural membrane. And in all probability what happens during early independent existence is only a repetition of what occurred prior to birth. I will revert to this point later.

The sutural bones that appear at certain definite sites have received special names. When situated over the posterior fontanelle a sutural is called an "epactal" bone, that which appears over the anterior fontanelle has been named the "os antiepilepticum." Béclard purposes to call the wormians that appear in in the temporal fossa the "crotophal" bones. When a sutural bone is found at the pterion it is termed "epipteric." This bone will be alluded to in my description of the variations in the pterion.

I carefully examined every skull as to the frequency and distribution of these bones. I have arrived at the conclusion that they are not indicative of any racial characteristic whatsoever.

I found sutural bones present in the skulls of 41% of all the races taken collectively. I note the percentages found in some of the races in the collection. New Guinea 80%, Burmese 67%, South American Indian and Negro 60%, Australian 54%, South African 45%, Irish and Scotch 40%, French and Egyptian 30%, Sand-wich Islands 27%, Esquimaux 17%.

Considerable variation is found between those races occupying the extreme ends of the series, but the difference is merely incidental. This is confirmed on reference to the percentages of other observers. Williamson after examination of the skulls in the Army Medical Museum, Chatham, finds wormians occurring with equal frequency in Negro and European crania. In my series the frequency in the Negro crania happens to be one-third more than in the Europeans. Charles found sutural bones in 60% of the Hindoo skulls he examined; I found a frequency of 26% in my series.

series. But in the individual skull wormians appear at certain sites with greater frequency than others. I found them of far greater frequency in the lambdoi -dal than in any other suture. The figures of other observers are in accord. I illustrate this by refer -ence to one or two races. In a collection of 74 Australian skulls, wormians were present in 42; in 29 out of these 42 they were present in the lambdoidal suture. In a collection of 40 Burmese skulls 27 possessed sutural bones, in 17 instances they were present in the lambdoidal suture. In the 7 Egyptian skulls with sutural bones, they were found in 5 skulls to be in the lambdoidal suture.

The site next in frequency was the squamosal suture--that is including the epipteric at its anteri -or extremity.

They were of frequent occurrence in the masto-occipi -tal suture. Out of the 42 Australian crania with wormians, in 11 skulls they appeared in this suture. They were present in this situation in 5 Burmese skulls. In 5 Australian skulls and in 5 Burmese skulls I found wormians in the coronal suture.

The occurrence of these bones in the sagittal suture--excluding those in the fontanelles at its extremities --I found to be rare. The Australian and the Burmese each contributing a specimen where suturals were present in the sagittal suture between the fontanelles

fontanelles.

These bones are not limited exclusively to the sutures that intervene between the bones that bound the cranial cavity. In a few instances I found wormians on the internal aspect of the orbit in the fronto-eth-moidal suture. This was present in an Australian from Gipps Land.

In a skull from Assouan, Upper Egypt I found a lozenge-shaped wormian on the outer wall of the left orbit, in the posterior reaches of the fronto-sphenoidal suture. The bone measures 8mm. in the line of the suture and is 4mm. in its vertical diameter.

In a Sandwich Islander B. a small wormian was seen between the os planum and the lachrymal on the left side.

In an Australian from Murray River district, two small sutural bones were present on the palatal surface, symmetrically disposed on either side of the inter-maxillary suture posteriorly.

These bones are usually arranged symmetrically.

Some skulls exhibit very perfect symmetry, as is well seen in an Irish skull H.T. 20 where a sutural bone is present in the outer reaches of the coronal suture, on either side, and within a few millimetres of being equidistant from the bregma. These bones are not quite the same size, the larger wormian being nearer the

the bregma by the same number of millimètres as it exceeds the diameter of its fellow wormian in the line of the coronal suture.

An Australian skull from the collection of Monro iii$\underline{\text{ius}}$ and a Guanche skull are good examples of the symmetrical disposition of these bones in the lamb-doidal suture. In 10% of the Burmese skulls a wormian occupied the asterion on both sides. When no symmetry can be made out, and the wormians appear un-mated, this is undoubtedly explicable by the wormians on the opposite side of the skull having become weld-ed to one or other of the bones between which they were interposed.

Wormians have often been described as occurring in various orders of mammals. They are said to be of rare occurrence in Leporines, but four cases are on record, one in "Lepus variabilis" described by Wenzel Gruber, and the others in the sagittal and coro-nal sutures of three rabbits described by G.B.Howes. It is not without interest to recall the median and lateral rows of plates in Ganoid fishes in this connec-tion. At birth the fœtal head possesses a fontan-elle at each of the four angles of the parietal bones. The median and superior angles of the parietals are in apposition, the antero-median angles meeting at the bregma the postero-median angles at the lambda. In

In addition to these so-called "anterior" and "posterior" fontanelles of the fœtal head, there are fontanelles at the inferior and lateral angles of the parietals anteriorly and posteriorly on both sides. Sometimes a fontanelle occurs in the sagittal suture between bregma and lambda. Dr Humphry saw several, and Dr Berry Hart has a skull showing this fontanelle in his collection.

It is interesting to note the frequency with which sutural bones appear at areas corresponding to the sites of these six fœtal fontanelles.

The epactal bone--either single or multiple--at the lamb -da was one of the most frequent sites of wormians in the whole course of the lambdoidal suture. This either appeared as a small bone just cutting off the superior angle of the occipital bone, or several small wormians are grouped together at this point. In a considerable number of cases the epactal bone was of large size, approximating that of the inter-parietal bone, but is readily distinguished from the latter by the fact that the suture which separates the inter-parietal from the occipital runs from asterion to asterion, whilst that separating the epactal bone from the occipital runs invariably at a higher level.

The wormians are very frequently represented at the area corresponding to the antero-lateral fontanelles

fontanelles by the epipteric bone. This bone was present in 19.2% of all the crania examined--being the most frequent site after the lambdoidal suture. This bone is usually single but I have found as many as three epipterics on the same side of the skull. The postero-lateral fontanelle represented by asteri-on is also a very frequent site of sutural bones. In the 27 Burmese skulls that possessed wormians they were present in the asterion in 12 specimens. They had the same frequency of occurrence at the asterion in the Australian crania.

I have detailed this point as I do not find it pointed out by observers that wormians are present in the great majority of cases at the areas corresponding to the position of these six fœtal fontanelles.

Sutural bones exhibit marked variations in size. They frequently appear as miniature ossicles a few millimètres in diameter; in these cases they are often present in considerable numbers. At other times they appear as large plates covering in comparatively large areas of the cranial cavity. The largest wormians are those that were formed in the earlier stages of ossification and have remained distinct. The epactal bone as already alluded to may attain a large size. In a New Guinea skull No.9 the right limb of the lambdoidal suture was almost taken up in in its entire extent by a large wormian, which was 54mm. in diameter measured in the line of the suture, and it measured 40mm. at right angles to the line of the suture.

A Peruvian skull from Pasamayo presents a condition of great interest. In the right limb of the lambdoidal suture a large wormian is present measuring 51mm. in the line of the suture. Between the central part of this sutural bone and the right parietal what I term "secondary" wormians were present. They are three in number. They are slender and elongated ossicles their long axes being at right angles to that of the "primary" large wormian. In this connection I may state that I found in several skulls distinct islands of bone incorporated in the parietal near its posterior margin. Other observers state that these bones are not invariably found in the sutures. But at one time these islands undoubtedly were placed in the suture. It may well be asked by what process have these wormians become incorporated in the substance of the bone. Two explanations suggest themselves.-

(1) That they have been completely enveloped by the margins of the bone which exhibit great activity in forming bone, and the flowing tide of ossification insulates the sutural bone.

This is entirely at variance with the explanation that

that has been formulated to account for the presence of wormians, and which I notice is accepted and advocated by all observers. At the present state of our literature on these bones, it is believed universally that they are stop-gaps developed in the membrane, when, from some reason or other, the usual ossific centres are unable to entirely cover in the cranial cavity. The centres that give rise to these suturals are regarded as emergency centres of ossification, that come to the rescue when any part of the cranial cavity is threatened to be left without a bony covering.

(2) The second explanation, which I believe to be the correct one, is that these bones are incorporated in the substance of--say the parietals-- by the obliteration of the suture between other wormians and the parietal bone. In the Pasamayo skull with "secondary" wormians, it is readily understood that the "secondary" wormians would become incorporated in the right parie-tal if the suture between the "primary" wormian and that bone became obliterated. It is an open question whether the ossicles I term "secondary" wormians were developed before the large wormian in the lambdoidal suture, and then the other wormian growing at a much quicker rate and pressing the other wormians between it and the parietals: or were they developed secondarily in the suture between the large wormian

wormian and the parietal. In any case what happens is that other sutural bones become formed and suturals showing a great tendency to remain separate being between these and the parietals, these combining suturals fuse with the parietals on both sides of the suturals that tend to remain separate and so they become enclosed in the bone.

What I have described is rare and occasional, but accounts for the small islands of bone that have from time to time been noticed near the posterior border of the parietals, and near the borders of other cranial bones.

I venture to suggest an explanation of the manner in which the flat bones of the skull increase in area; the same explanation gives the "Raison d'être" of the sutural bones. Many observers have noticed these sutural bones in early independent life to combine with one or other of the bones between which they are placed. In the infant skull these bones rapidly form in the sutural membrane and very readily coalesce with one or other of the bones between which they are placed. This process is active in the sutural membrane that lines the cranial plates circumferentially. This explains the peripheral extension of the cranial bones. What has been taught is that growth which takes place at the margin of the large bony plates

plates is the result of one or two centres of ossification in the case of the parietal, and that the activity of those centres finds expression all along the peripheræ of the parietal bone. The occasional persistance of a fontanelle at the inter-foraminal part of the sagittal suture seems to suggest a meeting-point of anterior and posterior areas. It is now generally stated that the parietals arise from two centres an upper and a lower and the rare condition of a divided parietal is quoted as confirmatory of this.

A similar process is said to occur at the margin of the other bony plates. The proposition that I hope to substantiate is that the cranial bones grow at their peripheræ by the welding of bones formed by distinct ossific centres in the sutural or fontanellar membrane; the rate of production of these suturals and their tendency to remain distinct as well as the rate of growth of the skull as a whole varying according to intra-cranial tension.
During fœtal life many centres of ossification appear in the membrane enveloping the brain. The great feature of prenatal ossification of the cranial bones is the great tendency that these areas of bone formed by the various centres in the membrane, have of welding with other areas of bone after a definite

definite plan. Postnatal ossification is only the completion of the same process of ossification that started during intrauterine life by the repetition of exactly similar stages to those of prenatal ossification--the membrane in which the centres of ossification arise having now been limited to the sutures and fontanelles.

Symmetry is also a constant feature of the fœtal ossification of the skull. Centres arise and form bone which welds with that formed after a definite plan with the result that one half of the skull is the exact counterpart of the other. After birth symmetry is also a constant feature in the ossification that takes place in the sutural membrane. The wormians that remain distinct in the sutures have frequently been described as symmetrical on both sides.

I found this well marked in the skulls I examined--some very typical specimens I have already alluded to.

Sometimes areas of bone that unite during fœtal life or early independent existence, remain permanently separate, as the presence of an interparietal bone and the persistence of the frontal suture.

This is not the result of the want of vigour in the process of bone formation, but is an

an expression of the tendency of the various areas of bone to remain separate.
Wormians have always been described as stop-gaps where ossification of the different centres does not proceed with enough vigour to cover in the cranial cavity. This is conspicuously false as they are most frequently found to be characteristic features in skulls which exhibit the most vigorous ossification. This tendency to remain separate is associa-ted with increased cranial tension. As when large quantities of fluid gather in the ventricles of the brain in a case of hydrocephalus, the process of bone formation is the same, but goes on at a more rapid rate and shows a greater tendency for areas formed by the various centres to remain separate. As a proof of the former it is only necessary to glance at the cranial bones of a healthy child and compare them with those of a hydrocephalic child of the same age: in the hydrocephalic skull the cranial plates are far more extensive.

It is equally true that when intra-cranial tension is increased the products of this increased formation of bone have a greater tendency to remain separate.
Papillault has pointed out the correlation between a persistency of the frontal suture and the increased development of the frontal lobes of the brain. In

In hydrocephalic crania or in rickety crania complicated with hydrocephalus, a divided frontal and a segmented occipital are very frequently met with.
What occurs under these conditions in the prenatal ossification in membrane is precisely what happens under the same conditions in the ossification that takes place in the sutural membrane after birth.
When cranial tension is increased the process of bone formation goes on at a more rapid rate in the sutural membrane, and here again there is a distinct tendency for these postnatal areas of bone to remain separate.
As it has often been pointed out that wormians are very characteristic of hydrocephalic crania: they appear linearly in the sutures and may form several rows. The presence of these sutural bones in such great numbers being due to the rapid rate of growth coupled with the marked tendency for bones formed in the sutures to remain separate in those skulls where intracranial tension is increased.
This is also exhibited under similar conditions in the permanent segmentation of the determinate cranial bones. In the cases described where hydrocephalic crania have no sutural bones, the effusion of fluid to the brain ventricles must have abated, then with diminished intracranial tension the welding together of the suturals with the cranial plates is readily

readily understood.

The presence of wormians in hydrocephalic crania is so marked that Blumenbach concluded that all skulls where they are found are only instances of hydrocephalic skulls in which the effusion into the ventricles had abated.

Hydrocephalic skull No.3487 in the catalogue of the Royal College of Surgeons London, possesses a strong bony plate running continuously in the middle line from the occipital bone to the ethmoid, between the parietals and between the two lateral halves of the frontal. Traces of a suture are seen at intervals at the middle of this plate running antero-posteriorly. These are evidently the sutural bones formed in the sagittal and midfrontal suture which have become united together into one mass but have failed to unite with the bones between which they are developed. At intervals the united suturals of the one side become welded to those of the other side at the places where the frontal and sagittal sutures are obliterated.

This specimen is of great interest as it indicates the growth of the skull in breadth by the formation of suturals which in this instance have become united together in one mass and have not as usually happens combined with a parietal or one or other half of the frontal. In a hydrocephalic skull in my series two

two large wormians were present at the lambda. They were separated mesially by a suture. On the left side it is interesting to note that the suture between the wormian and the occipital bone was obliterated for more than half its course.

I have determined the fact that wormians do fuse with the cranial plates in the hydrocephalic skull referred to H.T.394. In this skull a large wormian is in the act of combining with the occipital squame. Usually the sutural bones seem to combine very readi -ly with the bones between which they arise, and thus it is very rarely that a suitable specimen with the suturals partly fused with the bones of the skull falls into the hands of a capable observer. The skulls that would most likely exhibit a sutural in the act of combining are those in which there is a tendency for the bony areas deposited in the membrane to remain separate, in these skulls union would proceed at a slower rate. It was in such a skull that I determined the act of union.

In this relation I may refer to the suturals some -times incorporated in the various cranial bones without becoming completely fused with them. This is additional evidence in favour of my explanation of the manner in which the cranial plates increase in area. J.F.Meckel describing the wormians in relation

relation to the bones of the skull states that "They unite with them in one mass when the development proceeds regularly." But no observer has hitherto associated these sutural bones with the manner in which bones formed in membrane increase in area.

My proposition is further corroborated by a reference to rickety skulls. The great feature of cranial ossification in the case of rickets is that it is <u>retarded</u>. The <u>process</u> differs from that of a healthy skull only in the <u>rate</u> at which the formation of bone takes place. So when the process is gradual we can ascertain more readily the stages of the process. In a rickety skull we can follow up the process by gentle gradations and see precisely what happens. It is a matter of common observation that the cranial plates in rickety infants are lined circumferentially by wormians, which exhibit but little tendency to unite with one another or with the bones between which they occur. This is what happens ordinarily but at a far quicker rate, and the suturals exhibit greater tendency to combine with one another and the bones between which they are interposed.

Some might contend that a rickety skull is pathological. This is readily granted: what I hold is that the rickety condition does not change the nature of the process of ossification only the rate.

The marginal digitations so characteristic of the

the cranial bones is additional evidence in favour of my contention. Sutural bones as they increase in size encroach upon both bones between which they are placed, when it combines with one of the bones, there is no longer a sutural bone but a digitation jutting into the other bone. The larger a sutural becomes before it unites the more prominent will the digitation be after union takes place. It is interesting to note that my proposition incidentally explains the marginal digitations of the bones of the skull.

Mr Bland Sutton in his valuable memoir on the pterion discusses the significance of the epipteric bone. He states that an epipteric is normally developed in that position and the fact that it is not constant in its union gives rise to the different articulations between the bones that enter into the formation of the pterion. It usually unites with the great wing of the sphenoid and that articulates with the parietal, but it may unite with the squamous temporal so as to produce a squamoso-frontal articulation. This is but the truth partly told. What really happens at the antero-lateral fontanelle is that ossific centres form from time to time in the membrane, and the bones formed from these centres become one after the other united with the bones bounding the fontanelle. Or they may become welded with one another

another prior to their union in the manner described. Or they may remain separate and appear as epipteric bones. What is above stated by Mr Bland Sutton is correct so far as it goes, but it is incomplete. It is not only normal for one bone to develope in this region but for a great number from time to time which become united to the bones that bound the fontanelle. I have seen as many as three remaining persistently separate in the same pterion. These are wormian bones in the region of the pterion and are the homologues of the os *anti-epilepticum* and *os epactale* in the anterior and posterior median fontanelles. What occurs at the fontanelles is true of all the cranial sutures. Ossific centres appear in the sutural membrane. They either unite with the bones that form the suture or they may unite with one another repeatedly and the result of this interunion becomes in its turn united with one or other of the determinate bones of the skull to which it is in relation. The result of one centre or the united results of two or more centres may also remain permanently separate in the sutures or at the sites of the fontanelles as wormians.

The occurrence of wormians in the frontal suture is rare, as the suture itself exhibits such great tendency to be obliterated early in life. And I always noticed that a sutural bone has a far greater

greater tendency to unite with the bones between which it is produced, than these bones have to unite with one another. The persistance of a frontal suture is but seldom met with, but a wormian in the frontal suture which has not become welded to one or other of the lateral halves of the frontal bone is extremely rare. The most likely time to witness this would be when the suture is open in early life and when in addition ossification is retarded. I find one case recorded by Dr Gulliver where extending into the frontal suture from the membranous margin of the fore part of the anterior fontanelle was a large bony plate on both sides. The conditions under which I expected wormians to occur in the frontal suture are exactly those present in the case recorded. The skull was that of an infant four months old,and in ad -dition there was retarded ossification,the pre-maxil -lary bones were entirely separated from the superior maxillary bones, and further there were great numbers of sutural bones present. This case is one of great interest as the stage in development of the bones of the skull is that which corresponds to a state of things that is usually only found during fœtal life as the entire separation of the intermaxillæ from the superior maxillæ is but rarely seen after birth. The condition of things in this skull is presumptive

presumptive evidence that suturals are formed during fœtal life and not as Béclard contends exclusively after birth. What Gulliver noticed in the frontal suture of this infant with retarded ossification is what happens during the fœtal life of every infant, ossific centres appear in the frontal suture, plates are formed which become united with one or other of the lateral halves of the bone. That is in other words that ossification in the skull proceeds both before and after birth by the repetition of one and the same process. What is seen in this specimen is a state of things in the frontal suture which are usually limited to fœtal life. A parallel to this is seen in other sutures later in life before they also become obliterated.

At an early stage in fœtal life centres of ossification appear in the membrane lining the brain, as brain growth proceeds new centres appear and bone formed by these combine with the bone formed earlier by other centres. This proceeds and at birth we usually get a definite number of bones present. But not unfrequently some of the areas formed do not unite in the usual manner so that one or more of the determinate bones may be segmented. As brain growth proceeds after birth precisely the same thing occurs in the membrane now restricted to the sutures and fontanelles.

fontanelles. New centres appear in this membrane and bone formed by these centres readily unites with the margins of the bony plates that are in relation to them. This process is repeated until brain growth ceases. In prenatal ossification of the skull I have already pointed out that areas of bone which are the result of the activity of several centres united together, may not unite with areas which re-present the combined results of the activity of sever-al other centres. So that we get a segmentation of one of the determinate bones of the skull. This is what happens after birth, some of the products of the bone forming centres in the sutures may remain perman-ently distinct as wormians.

Additional evidence in favour of my explanation of the ossification of the skull is given by Henry Gray in his text-book of Anatomy, 14th Ed. 1897. He figures the norma verticalis and the norma latera-lis of a skull <u>at birth</u>. In fig. 155 two wormian ossicles are seen in the membrane of the anterior fontanelle in relation to the margin of the left frontal plate. In the left antero-lateral fontan-elle in the same skull (fig. 156) there is also a very distinct wormian--the epipteric bone of Flower. Accepting these data as correct I am in a position to state that the formation of wormian bones <u>prior to</u>

<u>prior to birth</u> is a determined fact. And Béclard's view is thus untenable. I have had no time nor materi-al to record teratological observations on this point which is of extreme interest, as it offers an entirely new, and I believe correct, explanation of the ossification of the skull. Thus my conclusion is that the intrinsic cranial plates are not formed by the determinate number of centres of ossification described in text-books, and that each area that is described as being formed from one centre is in reality the result of the union of areas of bone formed by many centres. In conclusion I refer to the recent trend to describe the ossification of the cranial plates as having taken place at more numerous centres than was hitherto supposed. I instance the parietal bone. It used to be described as formed from one centre. At present it is generally accepted that two centres are concerned,--an upper and a lower. It is likely that more centres still are about to be described as forming the parietal as the "sagittal" fontanelle seems to indicate the point of union of anterior and posterior areas. And in addition I note that the skull at birth already referred to as figured by Gray possesses fissures on both sides of the sagittal suture at the site of the "sagittal" fontanelle.

When brain growth is complete, and there is no no other condition present to increase the intracrani-al tension, then the process of bone formation in the sutural membrane becomes quiescent. Or when artifici-al appliances counteract the influence of intracrani-al tension at a certain part, the sutures of that area where pressure is applied tend to obliterate. As long as the intracranial tension is maintained no further change is seen in the sutures: but it is known that the brain shrinks with age and concomitant-ly with that we note that the suturals combine with the determinate bones of the skull and these in turn unite with one another. So all along the line there is a balancing between the state of intracranial tension and the processes that appear in the osteo-genic sutural membrane.

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PLATE I.

Skull of a Pondo Kaffir.

(1) Very large epactal bone. Smaller wormians are seen between it and the occipital and also in both limbs of the lambdoidal suture.

(2) Note that the suture that separates this bone from the occipital joins the limb of the lambdoidal suture above the asterion on both sides.

(3) Note also a wormian incorporated in the substance of the left parietal bone near its posterior border.

PLATE II.

Hydrocephalic Skull. H.T.394.

Two large wormians one on either side of lambda. This is the skull where I first determined the fact that wormians do unite with one or other of the bones between which they are produced. I have since seen a wormian in the process of blending in an adult Malay skull from Professor Spence's collection. The wormian on the left of the lambda has at two places fused with the occipital bone. This point is clearly shown in the photograph.

PLATE III.

New Guinea Skull. No.9.

Very large wormian present in right limb of lambdoi -dal suture, extending from asterion to within 2 centimètres of the lambda.

Its diameter is 54mm. in the line of the suture and 40mm. at right angles to the line of the suture.

Another wormian is placed between it and lambda.

Several small wormians are seen in the left limb of the lambdoidal suture.

PLATE IV.

Peruvian from Pasamayo.

(1) Large wormian in the right limb of the lambdoidal suture. It measures over 5 centimètres in the line of the suture.

(2) Three small "secondary" wormians are seen between this large wormian and the right parietal bone. Their long axes are at right angles to that of the large wormian.

PLATE V.

Irish. H.T.20.

(1) Persistent frontal suture.

(2) Wormians in the outer reaches of the coronal sutures on both sides.

This skull shows very well the symmetrical disposition of wormians.

The left wormian is nearer the bregma than the right wormian by the number of millimètres that it exceeds the diameter of its mate in the line of the coronal suture.

THIRD CONDYLE.-

In man as in all other mammals, there are two occipital condyles which articulate with corresponding surfaces on the atlas: amongst the Sauropsida there is only a single occipital condyle situated mesially in front of the foramen magnum, the basi-occipital and the ex-occipitals contributing towards its formation. In the Ichthyopsida there are two condyles formed exclusively by the ex-occipitals.
In rare instances in man an additional articulation occurs between the basi-occipital and either the anterior arch of the atlas, or the tip of the odontoid process. This articulation is either lateral or mesial at the basion.

The first mention of the "condylus tertius" is made by J. F. Meckel early in the century. He limited his observations almost entirely to European crania, and found one presenting this feature in a collection of over 400 skulls.
Dr Halbertsma describes it as occurring seven times in a collection of 876 skulls at Leyden, six of the crania being from the East Indian Archipelago, and only one being European. He regarded this as a racial character in the inhabitants of these islands.
Hyrtl describes a projecting process from the basi-

basi-occipital where its tip was adapted to a concavity in the anterior ring of the atlas. In a series of over 600 crania I examined it was found to be present in 9 specimens. It was present in two New Guinea skulls; the Australian, Sandwich Island, American Indian, Egyptian, Chinese, French and Scotch skulls contributing one each.

The lateral tertiary condyle might be explained by the articulation of the anterior arch of the atlas, with the border of the foramen magnum that is in relation to it, or the tip of the odontoid process might be tilted to one or other side.

In all cases this condyle appeared as an ovoid distinct shallow depression, with slightly raised margins, its concave surface contrasting with the convex surface of the lateral condyles.

The transverse diameters of this condyle ranged from 6-11mm. the antero-posterior diameter usually being about half the transverse.

Sir William Turner describes three skulls presenting this feature. He states that the lateral condyles sometimes exhibit a degree of flattening which is associated with the presence of this additional condyle. In the Scotch and French skulls possessing a third condyle the lateral occipital condyles were on both sides flattened to the extent that all the

the convexity of the condylar articular surface had been replaced by a plane surface. In the New Guinea skulls slight flattening of the left (lateral)condyle occurred in one skull; in the other skull the lateral condyles showed no flattening. In the Egyptian and North American Indian skulls no flattening occurred. Whilst engaged in my observations on this series of crania I often noticed an extreme flattening of the occipital condyles unassociated with the presence of the "condylus tertius."

Dr R. H. Charles refers to the paroccipital process as attaining a considerable size in all the Panjab crania that possessed the third condyle. In the nine skulls where it occurred in the series of crania I examined the jugular process of the occipital bone did not attain even the size of a tubercle.

Dr H.Allen describes ten crania in the Morton Collection possessing this condyle.

Dr Duckworth states that the occurrence of this condyle in the Gorilla is rare. He found it occurring once in a series of 109 skulls that he examined.

The third condyle is to be regarded as an individual variation that can be accounted for, and not a racial character.

From the basi-occipital bony processes were observed in several skulls. A number of these are

are situated on its inferior surface midway between the pharyngeal tubercle and the anterior margin of the foramen magnum. They occur either as spinous or tuberous processes mesially, as in two French, two American Indian, two German crania and in one Greek skull; or they may occur in pairs, symmetrically arranged one on either side of the middle line, as seen twice in Hindoo skulls and once in the Egyptian, French and Swiss skulls.

In an Indian skull a bony outgrowth appeared mesially on the anterior margin of the foramen magnum, and in a Hottentot skull a tuberous process was situated on the cerebral surface of the basi-occipital in the middle line 3mm. anteriorly to the border of the fora -men; it projected upwards into the skull cavity for 3.5mm. In one instance only,--that of the Esquimaux skull--did this process bear a distinct articular facet.

These bony projections that I have referred to as occurring in various situations on the basi-occipi -tal are, I find, described by Halbertsma. He terms them "processus papillares," and names them A. B. C. or D. according to the precise situations in which they occur. He describes them as a variety of the "Condylus tertius" of Meckel.

Some of these processes I noticed attained a consider -able size as in the skull of Joseph Kempff aet.45, a German, where a mesial projection was seen pointing

pointing downwards and forwards for 9mm. from the under surface of the basilar process in the middle line immediately in front of the foramen magnum. Dr. J. Barnard Davis describes these processes in seven skulls out of 140 Sandwich Island crania in his collection. He also noticed two in 7 Sumatra skulls, 1 in 18 Italian, 1 in 32 Dutch, 1 in 13 Scotch, 1 in 32 Chinese, 1 in 23 Dayak and 1 in 11 Fatuhivan skulls.

In front of the condyles the under surface of the basilar process is rough where the "rectus capitis major" and "minor" are attached. But the exact areas from which these bony processes arise do not coincide with those that serve for attachment of the muscles.

In a Guanche skull a distinct shallow reniform articular facet occurs on the external surface of the left exoccipital in close proximity to the postero-lateral border of the foramen magnum with which the long axis of the facet runs roughly parallel. In the recent subject it is seen that the superior fasciculus of the transverse ligament brings the tip of the odontoid process in relation to the occipital bone,--often when no facet is formed. Several axes have from time to time been described in which the anterior surface of the odontoid process bears two

two distinct articular facets, one for articulation with the anterior arch of the atlas and the other facet for the third condyle.

The occurrence of the third articulation is explained by Dr R. H. Charles in the case of the Panjab tribes by the fact that the Indian coolie places a load on his head rather than on his shoulders. The weight they carry on their heads being often very considerable this habit results in an increased strain on the occipito-atloid, and occipito-axoid ligaments, and a special adaptation of the parts occur to support the increased weight. And Dr Charles finds these ligaments well developed in the Indian coolie so as to cope with increased functional demands.

Ankylosis in this region has been described by various observers. Mr Bland Sutton observed this ankylosis common amongst oxen that were harnessed by the head. He attributes the occurrence to the third condyle, and this ankylosis, sometimes found in this region, to the effects of pressure from weights carried on the head. The occasional flattening of the lateral condyles seems to be additional evidence in favour of the "pressure" theory.

Dr R. H. Charles in his treatise on the third condyle in the Panjab tribes, groups the "condylus tertius" of Meckel, and the "processus papillares" of Halbertsma

Halbertsma in the same category of "third condyle." He states:- "The third condyle judging from these specimens, may be either an articular depression, a single and median tuberosity with an articular facet, a bilateral faceted tuberosity, or lastly an unilateral or bilateral non-articular tubercle."

Dr Charles attributes all these variations to the habits of the Indian coolie, carrying heavy weights (varying from 60-180 lbs.) on their heads.

The anterior arch of the atlas and the odontoid process of the axis are normally in close relation to the anterior border of the occipital foramen. It is thus readily understood how these weights carried on the head will result in actual contact and the formation of articular facets on the anterior margin of the foramen, either mesially or laterally. But the "pressure" theory does not account for the spinous or tuberous and conical bony projections that appear on the surface of the basilar process,--the great majority of which are devoid of a distinct articular surface. Some of the most projecting "processus pupillares" bear articular facets, as is the case in the Esquimaux skull described.

It is readily understood how these processes when they project far enough downwards articulate either with the atlas or axis as is the case with the paramastoid

paramastoid process articulating with the transverse process of the atlas.

But in what way does pressure applied to the head result in the formation of these projections remains yet to be explained.

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PLATE VI.

New Guinea Skull from Purari River District.

Third condyle is seen at the anterior border of the foramen magnum mesially. The left occipital condyle is flattened, the right is quite convex.

PLATE VII.

Esquimaux from Kotsebue Sound.

Halbertsma's "processus papillares" are seen on the under surface of the basi-occipital, one on either side of the middle line immediately in front of the anterior border of the foramen magnum.
The "median condylar foramen" is seen quite distinctly on the observer's ~~right~~ left side.

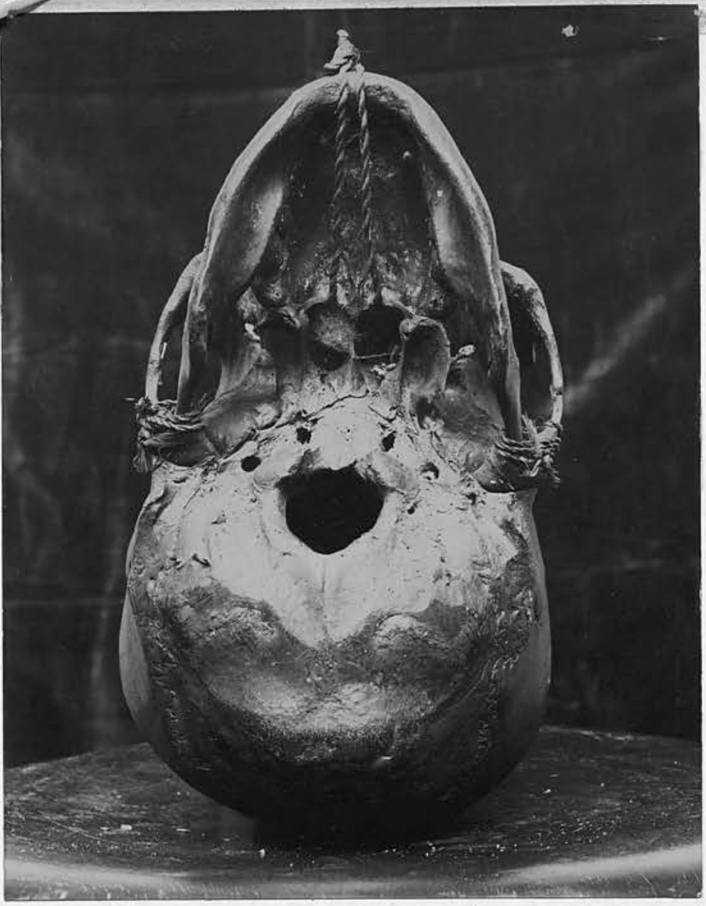
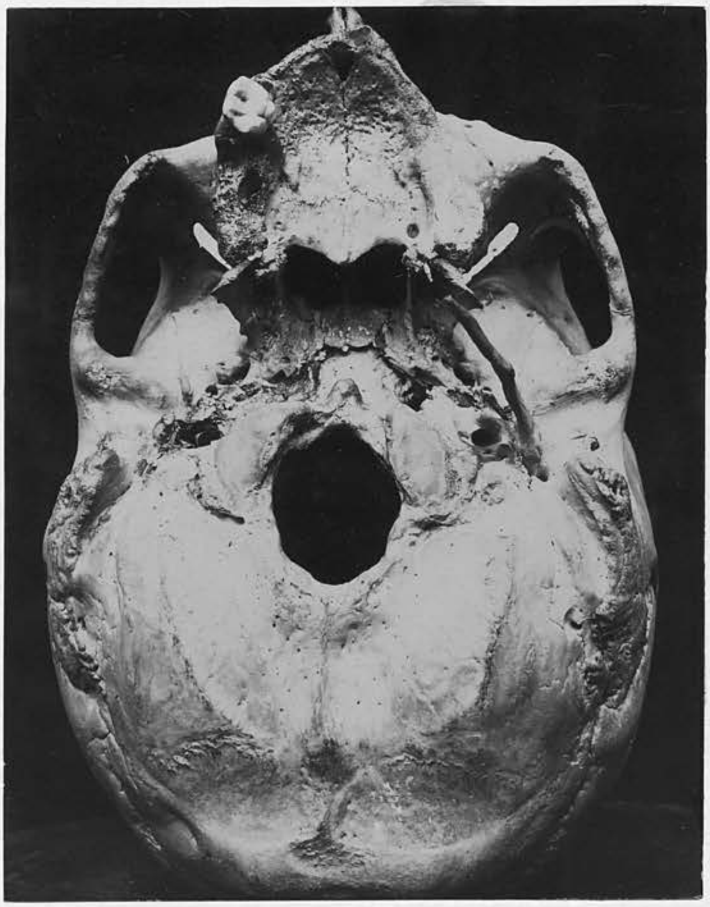


PLATE VIII.

Joseph Kempff, Aet.45. German.

1. Very prominent processus papillaris on the under surface of the basilar process of the occipital. It is situated in the middle line 2mm. anteriorly to the basion. It is a conical projection 7mm. in transverse diameter at its base and it projects downwards and forwards for 9mm.
2. The nasal spine of the superior maxillæ projects forwards as a ledge for 6mm.
3. The styloid process of the left temporal bone projects downwards for six centimètres.



PTERION.-

No stronger evidence could be adduced as to the validity of my explanation of the manner in which the cranial plates increase in area, than that it incidentally explains other conditions, which hitherto had not been adequately accounted for. I have elsewhere referred to it for an explanation when considering the significance of wormians and the denticulated margins of the bones of the skull. In addition it gives an intelligent interpretation to another keenly discussed subject--the variations in the pterion.

The pterion corresponds to the antero-lateral fon-tanelle of the fœtal head which is bounded by the frontal, parietal, squamous temporal and sphenoid bones. The fontanelle is covered in by membrane which is attached to the margins of the cranial bones that bound it.

The great membranous envelope which to a large extent covered the brain in early fœtal life is at birth narrowed down, and remnants are left at the fontanelles and sutures.

The fontanellar membrane is in relation to more than two bones, while the sutural membrane intervenes between the margins of two adjacent bones.

Broca has designated this area which is in relation to the great wing of the sphenoid the pterion. And

And Flower has termed these ossicles that remain persistently distinct at this area <u>epipteric</u> bones. Thus epipterics are wormians formed in the anterolateral fontanelle. Whilst restricting our attention to the pterion it is important to keep in mind that the process of ossification in this area does not in any way differ from that which occurs at other fontanelles and sutures. Neither does the process of ossification of the bones of the skull after parturition differ from that which took place during the fœtal stages of development. The fontanelles of the fœtal skull become closed up in exactly the same way as the osteogenic envelope has become narrowed down to the fontanelles and sutures. As evidence of this I note that Arthur Thomson found little osseous nodules evidently membranous in origin dotting the fontanellar membrane. Each osseous dot probably corresponds to a centre of ossification.

Henry Gray in his text-book of Anatomy figures the skull of a fœtus at birth where I notice two wormian bones present in the fontanellar membrane at the bregma in relation to the posterior margin of the left frontal plate. In the left pterion of the same skull there is a distinct epipteric bone. These ossicles have been formed during fœtal life.

The condition of things in this fœtal skull corroborates

corroborates my explanation of the mode of ossification of the bones of the skull and further proves the unity of the process both before and after birth.

Bland Sutton suggests that epipteric bones are formed in a plate of hyaline cartilage that is lodged in a fissure of the frontal bone that is in relation to the pterion. He noticed this in a colt's skull where the size of the orbito and the alisphenoids are reversed compared with what is found in man. He noticed ossification taking place at an independent nucleus in the upper extremity of the hyaline plate. He also noticed this cartilage present in a human fœtus at the fourth month; thus in early fœtal life the outer parts of the orbito sphenoids form part of the chondro-cranial wall. This observer states that epipterics are found in the cartilage left by the orbito sphenoids. Arthur Thomson combats this explanation. He examined the antero-lateral fontanelle in many fœtal heads and failed to find the cartilage that Bland Sutton described. He believes they are formed in the same manner as wormian bones.
Arthur Thomson remarks that epipterics for the most part must be regarded as fragments that have been separated from the alisphenoid or the antero-inferior angle of the parietal. This is erroneous. The various bony plates that form the skull never undergo

undergo fragmentation, except by physical violence. These bones are formed at different sites in the fontanellar membrane, and have not as yet combined with the bones of the skull that bound the fontanelle. The antero-lateral fontanelle is obliterated in the same manner as the other fontanelles; and the epipteric ossicles that remain separate correspomd to the os entiepilepticum, os epactale and the asterionic ossicles at the other fontanelles.

The situations in which epipterics are formed is strong evidence against the view that they are develo-ped in the orbito sphenoid cartilage as described by Bland Sutton. In a South American skull H.T.473 the epipteric bone on both sides of the skull extended from the frontal bone upwards and backwards into the squamosal suture for a distance of four centimètres. The great bulk of these epipterics is so placed that the cartilage of the orbito sphenoids could not account for them.

In an Australian skull from Roebuck Bay an epipteric extended for several centimètres beyond the site that Bland Sutton allots for the orbito sphenoid cartilage. This observer states that epipterics are always found in the skulls of young persons under 15 years of age. My results contradict this as I examined several skulls possessing the milk dentition in which no trace

trace of an epipteric was present on either side.
In these skulls many epipterics had undoubtedly from time to time appeared and had fused with the bones that meet at the pterion, thus obliterating the fontanelle. Bland Sutton regards the epipteric ossicle as differ-ing in its nature from the wormians and that it ought to be regarded as one of the intrinsic bones of the skull. He has endeavoured to show that it is a constant element in the pterion.
Centres of ossification appear in the fontanellar membrane at different parts. These deposits of bone may unite with one another repeatedly and thus form plates of considerable size. These fontanellar ossicles determine the various articulations found at the pterion according to the bones with which they unite. In a Burmese skull a quadrilateral epipteric separated the four bones that come into relation with one another at the pterion. It only remained for it to unite either above or below to produce the usual arrangement at the pterion, or if it fused anteriorly or posteriorly the skull would exhibit a squamoso-frontal articulation.
In an Australian skull H.T. 528 the alisphenoid was suddenly greatly increased in its antero-posterior diameter at the pterion. This is readily interpreted to signify that an epipteric of greater antero-posterior diameter than the alisphenoid has fused with it.

it.

In a squamoso-frontal articulation one or more epipterics have combined with the margins of the squamous temporal or frontal.

When an epipteric of large size welds with one or other of the bones, the relation between the four bones that meet at the pterion is to a great measure determined according to the plate that the epipteric unites with.

Bland Sutton states that one epipteric normally forms in the pterion. This is erroneous. What happens at each antero-lateral fontanelle I have fully explained. In about 20% of the skulls I examined one or more of the fontanellar ossicles remained persis-tently separate. These epipterics varied much in size shape and position, and consequently they had different articulations. Some articulated with the four bones that bound the fontanelle as was the case in the Burmese skull referred to. In a great number of cases the epipterics articulate with three bones; in the South American skull H.T.473 the lower epipteric on each side was bounded by the frontal and alisphenoid anteriorly and inferiorly, superiorly it was in relation to another epipteric.

In a Scotch skull H.T.417 there were three epipterics in the same pterion.

It may be taken for granted that only a small

small percentage of the plates formed in the fontanelle remained permanently distinct, and in the large majority of skulls all the epipterics combine with one or other of the bones.

The persistent epipteric is usually of considerable size--it being formed by products of various osseous centres exhibiting a greater tendency to unite repeatedly with one another rather than with the margins of the bones that bound the fontanelle.

Further evidence as to the mode of obliteration of the antero-lateral fontanelle is obtained by reference to two other skulls. One a Chinese skull marked M. which exhibited a squamoso-frontal articulation on both sides, but on the left side there was an epipteric bone capping the alisphenoid and separating the latter bone from the tongue-like process of the temporal squame which articulates for 12mm. with the frontal. The other skull is that of a Jollof Negro where there is a squamoso-frontal articulation on both sides, and a large lozenge-shaped epipteric is lodged between the tongue-like process of the squamous temporal and the parietal in each pterion.

These skulls are by no means solitary instances but are representative of a considerable number of skulls possessing these variations. The arrangement in the pterion in these skulls is of extreme interest as legitimate conclusions can be deduced from them as to to the manner in which the antero-lateral fontanelle becomes closed. In the Chinese skull M. several epipterics have undoubtedly combined with one another and also with the squamous temporal to form the tongue-like process by means of which this bone articulates with the frontal. But one epipteric remains distinct and is interposed between the alisphenoid and the other epipterics that had fused and now form the tongue-like process of the temporal bone. In the Jollof Negro skull there is a large epipteric placed between the parietal and the process of the squamous temporal which articulates with the frontal. In this skull the fontanellar plates have combined with the temporal squame at the lower part of the fontanelle, while at the upper part of the fontanelle they have repeatedly combined with one another forming a large epipteric which remains permanently distinct on both sides.

In the South American skull H.T.473 two epipterics intervene between the parietal and alisphenoid on both sides. In this case the epipterics have united together so as to form two plates one large plate formed by the union of bony areas at the upper and posterior reaches of the fontanelle, and a smaller plate representing the union of epipterics at the lower part of the fontanelle anteriorly.

I have coupled the discussion of the epipterics

epipterics with that of the various articulations found at the pterion as the mode of union or the persistence of these fontanellar ossicles determines the articulations that are found at the pterion. This explanation suggests that epipterics are of very frequent occurrence in the skulls of infants. This is precisely what occurs. Bland Sutton goes so far as to say that they are always present in skulls of young persons under 15. This observer has fixed the date of fusion toolate. He refers to the anterior fontan-elle as an "unclaimed area" or "debatable territory" and that the neighbouring bones of the skull "struggle for the mastery." This is a terse simile but it is incorrect in point of fact. It is not a case of the bones that bound the fontanelle struggling to cover in as much as possible of the fontanelle with bone; but the variations that occur at the pterion are directly attributable to the conduct of the fontanellar ossicles according as to whether they remain distinct or according to the bone they decide to fuse with.

The variations in the articulations at the pterion have been tabulated by Broca.

1. Pterion en H. This is by far the commonest arrangement at the pterion. The upper part of the H. denotes the antero-inferior angle of the parietal, and the lower part the alisphenoid: the frontal and

and the temporal being on either side. Persistent epipterics variously modify this type.

2 Pterion en K. In this variety a process of the squamous temporal insinuates itself between the parietal and the alisphenoid to a variable extent--usually to within a few millimetres of the frontal bone. This arrangement was well exemplified in four Australian and in two South American skulls.

3. Pterion retourné. In these cases the squa-moso-frontal articulation is present. The extent of this articulation is very variable as is that between the parietal and the alisphenoid in the pterion en H. This pterion retourné is not unfrequently limited by persistent epipterics that intervene between the tongue-like process of the temporal squame and either the parietal or the alisphenoid. This is typically seen in the Chinese and Jollof Negro skulls that I have already described.

In some New Guinea skulls the squamoso-frontal articulation was over 20mm. in extent. In a South African skull H.T.203 this articulation only extended for 1.5mm. In this case other epipterics had united above and below to the parietal and alisphenoid. It is thus seen that the pterion retourné may become very limited as in the case of the pterion en H. when it becomes converted to a pterion en K.

Professor Sir William Turner first pointed out that

that the pterion retourné of Broca was of very frequent occurrence in the skulls of anthropoid apes at the Anatomical Museum of the University of Edinburgh. In other collections of anthropoid crania this articulation was found to be rarer.
I found it present in 5% of the skulls that came under my observation. It was most frequently met with bi-laterally and in exotic crania.

I note the following percentages:-
New Guinea 25%, Negro 22%, Burmese 10%, South African 9%, Sandwich Islanders 6%.
European races are represented by the French where this arrangement at the pterion was present in 5% of the skulls.
The significance of the pterion retourné is a moot point. It is true that it is of comparatively frequent occurrence in anthropoid apes, and is also most frequently met with in some of the skulls of primitive races of man. These seem to point it out as a reversion.
I am strongly of opinion that this arrangement at the pterion is nothing more than an individual variation. In support of my view I adduce the following facts.

(a) If it is reversion it would in all probability occur with comparative frequency among aboriginal Australian crania. But it was absent in the 74 Australian skulls I examined, and Arthur Thomson found

found it absent in the 41 Australian skulls he examin-ed at the Anatomical Museum of the University of Oxford. This gives a series of 115 Australian crania without a single skull exhibiting a pterion retourné.

(b) It has been described in the skulls of European races and it was present in 5% of the French skulls I examined.

(c) If it were a reversion we would expect to find it of more frequent occurrence in skulls that have been recovered from the different barrows than in skulls of men that live in modern times.
But it is a significant fact that hitherto no pre-historic skull has yet been described possessing a squamoso-frontal articulation.

(d) The explanation I gave of the manner in which the cranial plates increase in area throws light on all the variations that are found at the pterion. I have already pointed out whilst discus-sing the wormians, that the fusion of these bones with the cranial plates gives rise to the characteristic denticulations that are found at the margins of the bones of the skull. If the wormian is large then its blending occasions a very distinct undulation in the suture at that point. We have only to picture this wormian in the fontanelle to see how the various ar-ticulations are determined according to the bone it unites with. Very limited portions of the four bones

bones enter into the formation of the boundary of the fontanelle; it is thus seen that the manner in which a somewhat large epipteric combines with one or other of these bones readily determines the state of things that will be found in the adult skull. But what it is that brings about the union of epipterics of various sizes to different bones in different skulls, so as to result in a variety of articulations at this part remains yet to be explained. That these bones do combine in the way described is established by capable observers; and I examined several skulls where persis -tent indications of incompletely fused epipterics were present in the pterion.

In conclusion I will compare the pterion with the bregma. Four bones bound the antero-lateral and the "anterior" fontanelle. These fontanelles are obliterated in the same manner, and similar varia-tions result in the bregma as in the pterion.

The various articulations at the bregma are not so easily made out because the frontal suture in the great majority of skulls becomes obliterated in early infancy. So for the most part we have to limit our observations to metopic skulls. Professor Sir William Turner has pointed out that in these skulls the coronal suture is not unfrequently found to one or other side of the sagittal suture. I found this in several of the metopics I examined. And I saw in in several skulls the parietal bone of one side articulating with the frontal plate of the opposite side. These variations are brought about in the bregma by the manner in which the fontanellar ossicles weld with one or other of the bones that bound the fontanelle.

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PLATE IX.

North American Indian. H.T. 473.

Right pterion with two distinct fontanellar ossicles. The larger ossicle covers in the upper and posterior parts of the fontanelle. The smaller ossicle covers in a corresponding area at the lower part of the fontanelle anteriorly.
A similar arrangement is present in the left pterion.

PLATE X.

Australian.- Lower Murray District. N.S.W.

In right pterion a tongue-like process of the squamous temporal articulates with the frontal for 9.5mm. Between this process and the right parietal bone there is seen a fontanellar ossicle that has remained persistently separate.

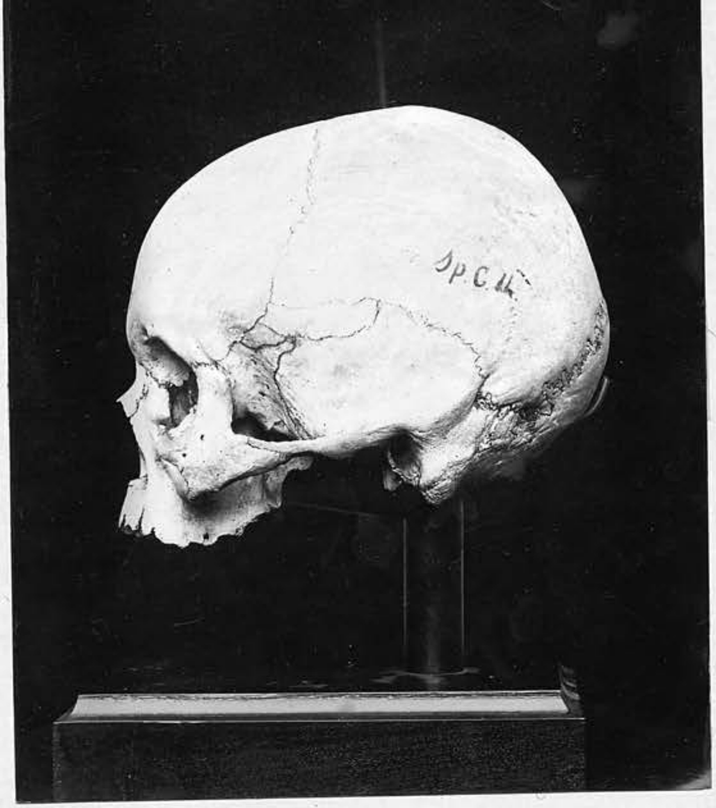


PLATE XI.

Two distinct ridges seen on the surface of both pari-etals. They run antero-posteriorly from the coronal to the lambdoidal suture. They join the coronal suture nearer the stephanion than the bregma.
The ridges end on both sides posteriorly midway between the lambda and the asterion.
These are interesting in relation to the condition of divided parietal. I examined the Australian skull that has been described and figured by Professor Sir William Turner in the Journal of Anatomy and Physiology 1891. I find that these ridges correspond in their course to the intra-parietal suture in the Australian skull.

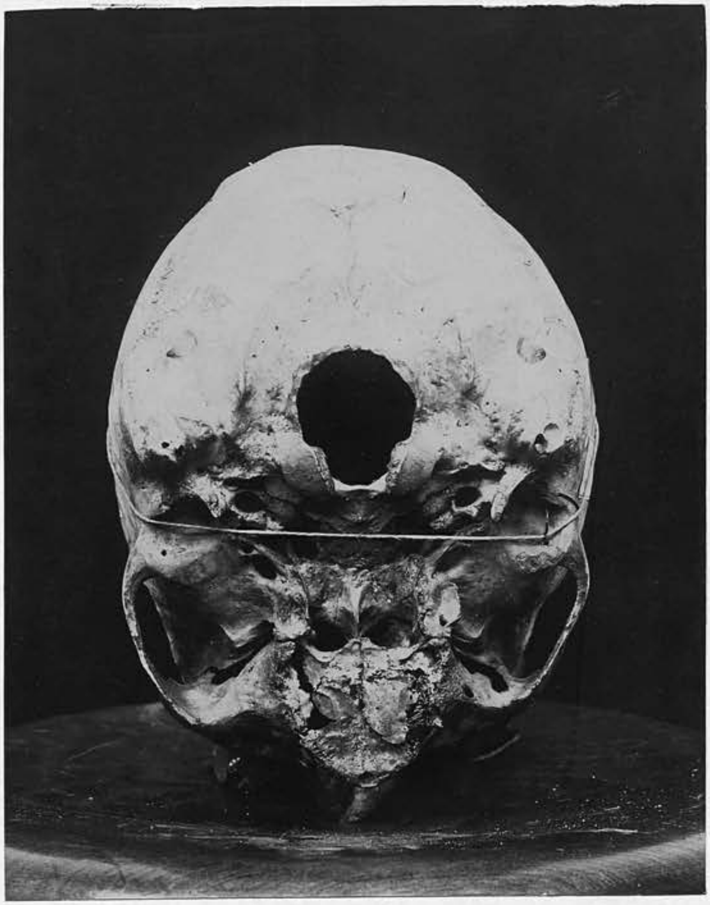
PLATE XII.-

Mastoid foramina exceedingly large on both sides.

Right mastoid foramen trans. diameter 8mm.
antero-posterior 6mm.

Left mastoid foramen trans. diameter 9.5mm.
antero-posterior 7.5mm.

It is interesting to note that the jugular foramina are very small on both sides. In all probability a large vein passed through the mastoid foramen on both sides: these drained away a great quantity of impure blood from the interior of the skull. This would result in the jugular veins being proportionately smaller.



DIVIDED MALAR.-

It is very seldom that the malar bone is divided completely into two parts in the adult human skull. When division occurs it is invariably by a transverse suture, an indication of which is not unfrequently met with at the zygomatico-malar articulation. The bone is unequally divided, the lower portion--the "ossa zygomatica accessoria"-- being always the smaller of the two.

Several instances of this interesting variation are on record. Sandifort was the first to describe a bipartite malar in a fœtus. Two skulls, possessing this feature, are described in the catalogue of the Vrolik Museum; in one of these the malar is divided on both sides. Negro skulls contribute two specimens, one described by Sömmerring, another by van der Hoeven; the skull described by the latter observer has the malar divided on both sides. Another divided malar is seen in a Japanese skull in the collection of the Royal College of Surgeons, London.

Dr Barnard Davis describes two divided malars in his collection of over 1500 skulls.

Rolleston refers to the divided malar as a characteristic of Bush crania. He found the malar to be divided either partially or completely in three out

out of six specimens. Following up his investigation he noticed several rudimentary sutures in the Bush crania at the Royal College of Surgeons, London. The skulls I examined not unfrequently exhibited a rudimentary suture running transversely on the outer aspect of the malar, for a few millimètres at the tempero-malar articulation. This indication of a divided malar was present in the skulls of most races. The Bush crania I examined did not possess one completely divided malar.

The whole series of 613 skulls did not possess a single malar where complete division was present. Dr A. B. Meyer in his communication to the Berlin Anthropological Society describes two skulls out of a series of 898 where the malar was completely divided. My observations indicate that it is a rarer condition, as I arrived at a negative result after examining over six hundred skulls which included skulls of civilised races as well as those of aboriginal man.

Garbiglietti regarded this bone, which is accessory to the "os jugale" to be the homologue of the tympano-jugal bone which is so characteristically seen in reptiles and fishes.

The transverse suture that is occasionally described as dividing the malar may be taken as the key to its

its development. Meckel states that his observations point that the bone invariably ossifies from a single centre. But the occasional division of the bone coupled with the frequent indications of the same condition indicate two centres as being concerned in the ossification of this bone. Spix and others describe the malar bone as arising from three centres of ossification. The union of these three ossicles is said to take place at the fourth month. If there are three centres concerned, two of these must always unite early in development as no tripartite malar has ever been described.

A divided malar in the skull of an adult is an instance of the early stages of development being rendered permanent. The indications of this division may be regarded as arrows that point back to an early period of development when the division was complete.

A parallel to this may be mentioned in the case of in-dications of an interparietal and a divided frontal that are so frequently met with.

The first description of a divided malar occurring in a monstrous fœtus is also significant, as variations in the form of preserved early developmental stages are often noticed in these cases.

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EXOSTOSES IN EXTERNAL AUDITORY MEATUS.-

From time to time pearly masses of bone have been described projecting from the wall of the external auditory canal into the lumen of the tube. They vary in position, size, number, form and area of attachment.

These exostoses may be single or multiple, and may occur either in one or both auditory canals. They occur most frequently on the surface of the tube in its outer half and arise from either the anterior or posterior walls or from the roof or base of the aural canal.

Variations occur in size. Some appear as faint ridges whilst others are so large as to wholly obliterate the lumen of the tube.

These outgrowths differ in their attachments to the wall of the auditory canal. In some instances exostoses appear as slight bulgings of the tube wall; in those cases the area of attachment is greater than that of the more projecting parts of the bony mass. The area of attachment may be of equal diameters with the projecting mass, or the exostoses at their attach-ment to the wall may be markedly constricted so as to become supported by a more or less slender stalk.

These outgrowths assume various forms. These I

I most frequently met with are:-

(a) Fungiform growths attached by a somewhat broad base.

(b) Pear-shaped growths with markedly constricted pedicles of attachment.

(c) Slight bulging masses so that the tube wall at that part presents a convex surface.

It is only comparatively recently that these aural exostoses have been described. Dr J. Toynbee states that it "Is a disease of no unfrequent occurrence." Professor Seligmann in 1864 described them as present in the external auditory canals of several deformed American skulls.

Dr J. Barnard Davis refers to several skulls in his collection with similar outgrowths in the auditory canal. He describes an ancient Roman skull with both passages obstructed with these bony growths to such a degree that must have resulted in deafness. Out of 28 crania from the Polynesian Archipelago a Fatuhivan skull, an Ohivaoan skull and an Nahugan skull possessed aural exostoses. In his fine collec-tion of 140 Sandwich Island (Kanaka) crania he found these processes present in four skulls. Four instances of these bony tumours are described by him in Peruvian skulls.

Professor Welcker describes these exostoses in two skulls from the Marquesas Islands.

Professor Sir William Turner draws attention to aural

aural exostoses exhibited by two skulls,--one a Peruvian, and the other a Chenook Indian. Professor Seligmann in his memoir states that five out of the six skulls presenting these growths were deformed and both skulls described by Professor Sir William Turner were also deformed. The latter observer naturally asks if there is any correlation between these exostoses and a deformed skull. After carefully balancing several considerations he believes that it is only a coincidence.

These exostoses were present in 4 out of 37 Sandwich Island crania that came under my observation. In 3 out of the 4 the processes were present on both sides. Dr J. Barnard Davis on examining the 140 Sandwich Island (Kanaka) crania in his collection noticed 4 specimens in which these bony processes were present, that is about 3%. The results of my examination of Sandwich Island skulls seems to point to a greater frequency--nearly 11%.

In B Oahu skull the right canal has two small exostoses jutting into the canal at different levels. On the posterior aspect there is a distinct bulging of the wall for 1.5mm., into the canal. This bulging runs inwards, upwards and forwards roughly in the long axis of the tube. The left auditory canal of the same skull contained two exostoses,one was a a broad-based bulging running inwards along the posterior wall of the tube, and takes the same course as in the right canal.

In S Oahu there is a small globular mass projecting for 2mm. inwards and backwards from the superior wall of the right auditory canal. It resembles a miniature fungus possessing a distinct pedicle.

In skull I Oahu the right aural canal contains two exostoses. One appears as a distinct inward bul-ging of the posterior wall. From the superior wall a pear-like growth projects downwards into the canal. In the left canal an exostotic growth appears on the outer third of the posterior wall inferiorly.
Another large exostosis is attached to the junction of the anterior and superior walls; it is pear-shaped and hangs downwards for 6mm.--within 1mm. of the base of the canal. It nearly occludes the whole lumen of the tube being in contact with the anterior and posterior walls, and only a narrow crescent-shaped opening remains between the bony tumour and the base of the canal.

In a skull from the Waimea plains exostoses were noted in both ears. They appeared as broad-based bulgings on the posterior walls; on the left side nearly half the lumen of the canal is blocked up.
South American crania contributed two skulls presenting

presenting this feature. One a greatly deformed Peruvian skull from Pisgua, in which the right ear was nearly occluded by a fungus-like exostosis. It was attached to the anterior wall by a markedly constricted base. The process is 5.5mm. in antero-posterior diameter and 4mm. vertically. There is a smaller exostosis with a broad base of attachment below it. On the left side two pisiform masses of bone of unequal size are seen in the canal. The larger is attached to the anterior wall by a broad base, the smaller is similarly attached to the posterior wall. An interspace of 1mm. exists between the two exostoses.

In a Coquimbo skull the bulging variety of exostosis is seen. In direction and amount of projection into the canal it resembles those already described. A precisely similar arrangement is seen in the Australian cranium. In the skulls examined the ridge-like bulging is limited to the posterior wall exclusively, and runs a course that is roughly parallel to the long axis of the tube. The fungiform and pear-shaped varieties may project from any part of the circumference.

These exostoses are not a race character, but an individual variation whose growth is encouraged by agencies that irritate the lining membrane of the

the tube. They may either be

(a) Cancellous when they usually are single and pedunculated and formed at the junction of the cartilaginous and bony meatus. These tumours are frequently met with in long bones at the junction of the diaphyses with the epiphyses. They are developed from cartilage, which is disposed over the most projecting part of the exostosis in the form of a cap. Dr J. Toynbee describes an instance where the membrane lining one of these aural exostoses was absent, and he distinguished a layer of cartilage on the surface capping the most projecting part of the bony tumour. These exostoses have been known to follow suppuration of the middle ear.

(b) Ivory Exostosis.- Dr Toynbee states that these are the result of a rheumatic or gouty diathesis. Dr Logan Turner states that they have been observed to be of greater frequency in races who habitually indulge in sea bathing. The presence of these exostosis in Sandwich Island skulls, and in crania from the Marquesas Islands Fatuhivan, Ohivaoan, Uahugan and other islands in the Polynesian Archipelago may countenance this suggestion. But in addition we find them in skulls of races who inhabit central tracts of great continents and the same explanation could hardly be brought forward to explain these.

these. But it seems probable that some previous irritation of the lining membrane of the auditory canal is favourable to the development of these exostoses. When Dr Toynbee refers to these aural exostoses as by no means of uncommon occurrence, he doesn't state that he keeps in mind that he is making observations on diseased ears. And as crania with diseased auditory canals form but a small percentage of the sum total of skulls, it is by no means surprising that they are not found and described oftener in the various collections of skulls.

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PLATE XIII.

Peruvian Skull from Pisagua.

(1) Exostosis in the right auditory canal. Its shape is suggestive of a miniature mushroom. It is attached by a constricted pedicle to the anterior wall, and projects backwards to within 1mm. of posterior wall.

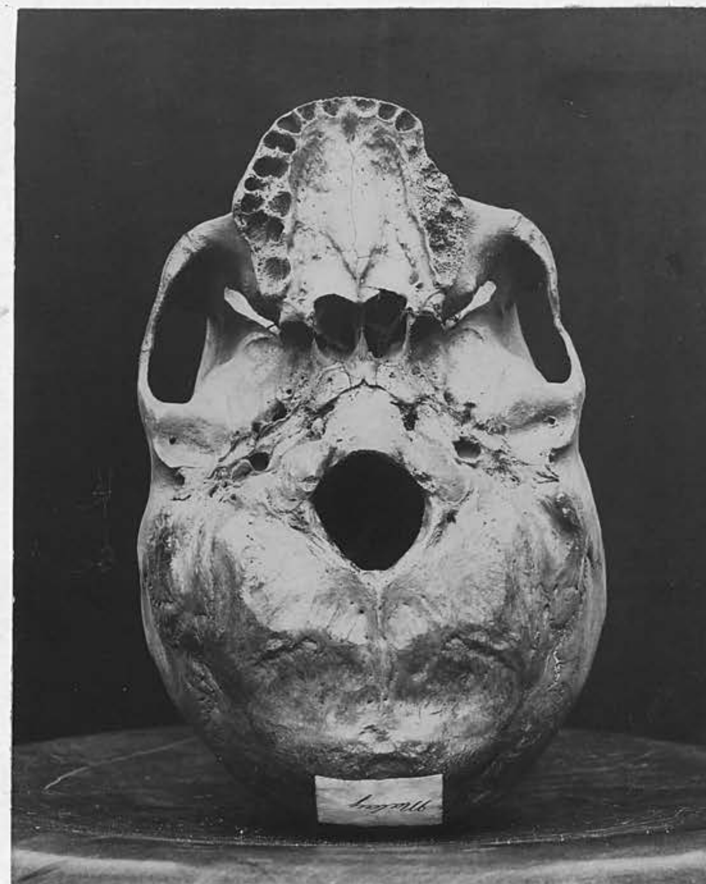
(2) Flattening over the frontal region.

PLATE XIV.

Malay skull from Professor Spence's collection which exhibits very marked boat-shaped bulging of the roof of the mouth. This bulging extends from the anterior palatine fossa to the posterior reaches of the inter-palatine suture. Midway between these two points the bulging involves two-thirds of the breadth of the palate and projects downwards for 6mm. It is very suggestive of a boat as its transverse diameter diminishes anteriorly and posteriorly and tapers to a point at the extreme ends of the palate in the middle line.

A Moriori skull and another Malay skull presented the same feature.

Professor Sir William Turner in his "Challenger" Report describes several skulls where a bony excres -cence appeared as a mesial ridge on the roof of the mouth being in intimate relation to the inter-maxil -lary suture. I found a similar condition in sever -al skulls--the excrescences being exceptionally well marked in a Fuegian skull and a French skull R from the Paris catacombs. This is to be distinguished from the boat-shaped palate as in the latter it is not merely an excrescence on the roof of the mouth but both superior maxillary bones are involved.



INFRAORBITAL SUTURE.-

A groove is seen on the floor of the orbit canal-ising the superior maxillary bone. It starts about the middle of the external border of orbital plate of the upper maxillary and runs forwards and inwards. When traced forwards on the floor of the orbit it becomes roofed in and then constitutes the infra-orbital canal. This opens on the facial aspect of the upper maxillary immediately under the central portion of the lower border of the orbit, and serves for the passage of the infraorbital vessels and nerves. Canals take their origin from the floor of the infraorbital canal anteriorly and posteriorly, and run downwards in the anterior and posterior walls of the antrum respectively.

In the development of the upper maxillary bone three centres appear in relation to the infraorbital canal. One centre lies internal to the canal and forms the internal portion of the floor of the orbit, the outer boundary of the nasal fossæ and the nasal maxillary process. Another appears externally and forms that part of the superior maxillary bone including its malar process. The great bulk of the bone is formed by the so-called "maxillary" centre below the infraorbital canal; this is hollowed out

out by the formation of the antrum. So this canal is an excellent landmark in the ossification of the upper maxillary bone.

I have noticed that the proportional length of the groove and the canal on the floor of the orbit is by no means constant. In some skulls the groove was roofed in a short distance behind the orbital border while in other cases the groove was covered in for about two-thirds its entire extent. This is inter -esting as it points out that in the human orbit we sometimes get an approximation to a condition present in lower forms of life, as Professor Sir William Turner has pointed out that in the anthropoid apes the canal is usually widely patent on the floor of the orbit.

Not unfrequently a suture is seen to extend along the roof of the infraorbital canal on the floor of the orbit, then crossing the border of the orbit, runs for a short distance along the facial aspect of the upper maxillary on to the superior border of the infraorbital foramen. Professor Sir William Turner in his "Challenger" Reports, describes and figures this suture in the adult skulls of primitive races of men. He has since returned to the subject and written an important article (in the Journal of Anatomy and Physiology Vol.XIX.p.218) in which he he points out that this suture is present in several adult European skulls. He further adds that this suture is almost invariably present in the infant skull.

On making investigations into the ossification of this bone we will find the presence of the infra-orbital suture explained. Callender has described the skull of a fœtus at midterm where the roof of the canal was wanting for its entire extent. He describes ridges of bone forming on either side of the groove and thus deepening it. The margins of these ridges arch over the canal approximating those of the opposite ridge, and finally the margins come into apposition forming the infraorbital suture; which remains open in a considerable number of adult skulls.

Gray figures a superior maxilla at birth where the roof of the infra-orbital canal is incomplete for its entire extent.

Professor Sir William Turner examined 28 young European crania which were collected without special reference to this point and he found this suture persistent in every skull. This indicates that this suture is normally present in early life; and from Callender's observations I conclude that what corresponds to the infraorbital canal in the adult is represented in the fœtal skull by a groove that is not roofed in at any point.

point. The "imperfect longitudinal suture" of Weber is seen on the facial aspect of the upper maxillary in this region and courses upwards and inwards on the nasal maxillary process. On close scrutiny it is readily distinguished from the infra-orbital suture as it is not in relation to the infra-orbital canal. The infra-orbital suture varies in its direction. It either runs directly upwards to the lower border of the orbit or it may deviate slightly to one or other side. In a considerable number of skulls I found this suture running upwards and outwards and cutting the malo-maxillary suture more or less at right angles. In these skulls no further trace of the suture was seen on the facial aspect of the upper maxillary above the malo-maxillary suture. I have examined several skulls where the suture cuts the lower border of the orbiton one side, and the malo-maxillary suture on the other. This was seen in a Russian No.3, German No.43, Greek H.T.70, Esquimaux H.T.235 and in a Swiss skull from the Rhone valley. In a considerable number of skulls the infra-orbital suture cuts the malo-maxillary on the facial aspect on both sides. This was present in 25% German, 18% Scotch, 12% Esquimaux and 9% Hindoo skulls. Supernumerary infra-orbital foramina were present on the left side in two skulls from the catacombs of of Paris. In French skulls Nos.22 and 23 supernumerary foramina were present on both sides; in the latter skull there were three on the left and two on the right side. In association with these supernumerary foramina I have noticed sutures running up to the floor of the orbit indicating a similar mode of development to that which Callender described in the case of the infra-orbital foramina.

Mr Bland Sutton has pointed out the frequency of supernumerary infra-orbital foramina in the chimpanzee.

Professor Sir William Turner states that the persistent infra-orbital suture is not limited to exotic races; and that it is of more frequent occurrence than Anatomists have hitherto recognised.

The results of my observations support these statements as I found it in 22% of all the skulls collectively and it was of more frequent occurrence in German skulls than in any of the aboriginal races.

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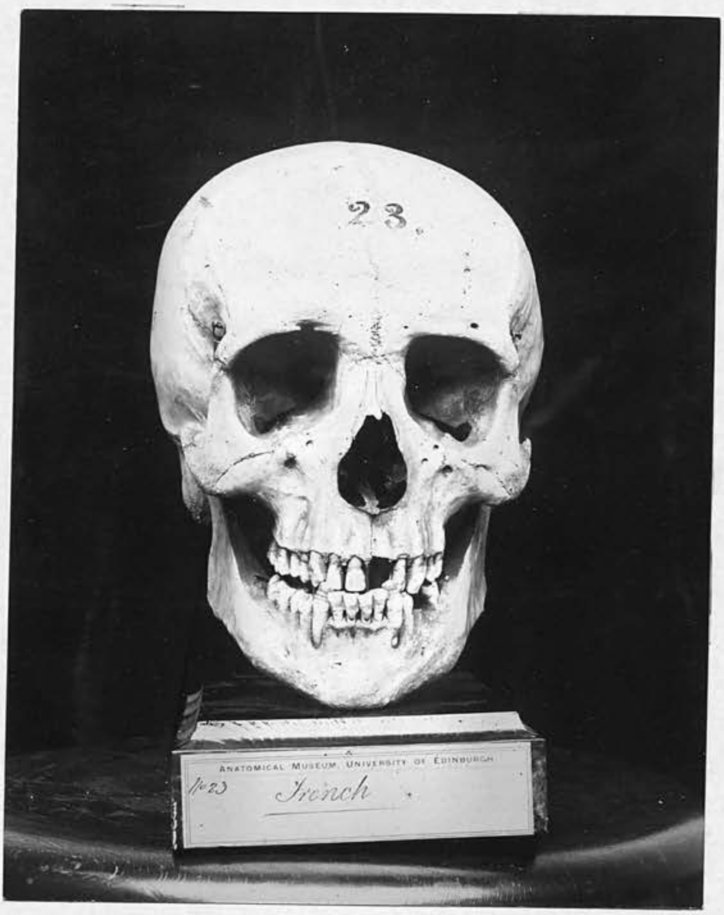
PLATE XV.

French. No.23.

1. Persistent and denticulated frontal suture.

2. Supernumerary infra-orbital foramina, two on the right and three on the left side.
On right side of skull a suture can be seen running from both infra-orbital foramina to the lower border of the orbit.



23.
ANATOMICAL MUSEUM, UNIVERSITY OF EDINBURGH
No 23 French

PARAMASTOID PROCESS.-

This term is regarded by Macalister as synonymous with the paroccipital process, and he speaks of the downward prolongation of the jugular process of the occipital as "The paramastoid or paroccipital process." Corner in his description of the processes in the occipital and mastoid regions of the skull, limits the term paramastoid to the process at the inner lip of the digastric groove. Morris refers to the prolongation of the jugular process as the "paroccipital" It is clear that the term is applied to different processes and used synonymously with other terms. In my description I limit the term paramastoid to the downward prolongation of the jugal process of the ex-occipital which is occasionally seen in the human skull. It is to this part that the "rectus capitis lateralis" is attached. In most skulls the surface of the jugal process is rough or a rudimentary tubercle may be present.

This process is constantly present in mammals, and is very well developed in herbivora. Corner has described it in the Orang, Cercopithecus and Cebidæ. In man the inner lip of the digastric muscle is attached immediately internal to the mastoid process. In lower mammals such as the horse and ox which possess

possess very prominent paramastoids the inner lip of this muscle is attached more internally--the exact area being indicated by the projecting paramastoid. In this way Corner establishes a relation between the origin of the inner bundles of the digastric muscle and the presence or absence of this process.

The paramastoid is present in a North American Indian skull in the Museum of St Thomas's Hospital. The most projecting part bears an articular facet.

Another well-developed process in one of the skulls of the Nor. Hum. Ost. Ser. projects to a lower level than the mastoid process and presents an articular surface. It is the skull of an aboriginal from the Philippine Islands . Two crania presenting the same variation are present in the Museum of Anatomy at Dublin.

Dr R. H. Charles describes this process as large or prominent in 28% of the Panjab crania that came under his observation.

Dr J. Barnard Davis refers to several skulls in his fine collection possessing a paramastoid. 1 in 17 Ancient Roman, 1 in 7 Polynesian, 1 in 39 Irish, 1 in 25 Javan, and 3 in 140 Sandwich Island (Kanaka) skulls. In two out of the number the process was faceted at its tip. When taking my observations I passed by the small tubercles and the roughness which were almost invariably seen on the outer surface of of the jugal process, and the following remarks are descriptive of tuberous masses or tuberosities of considerable size.

(1) The Paramastoid as a Faceted Process.- This was present in two skulls, and possibly a third skull, in a series of 613. In all cases the faceted paramastoid was unilateral. In a Sandwich Island skull marked D Oahu the paramastoid was prominent, projecting downwards, outwards and slightly backwards for 8.5mm. from the surface of the left jugal process. In general contour it resembles an inverted mushroom--the most projecting part of the process bearing the facet is increased in all diameters.

Head:-	Antero-posterior diameter	8mm.
	Transverse -	9.5mm.
Stalk:-	Antero-posterior diameter	6.5mm.
	Transverse -	7mm.

The process is faceted inferiorly and externally at its most dependant part.

The South Africans contribute another prominent faceted paramastoid. It is seen in the skull of a Bojes-man. It juts downwards for 15mm. from the under surface of the occipital bone. At its base of attachment it is 10mm. in transverse diameter and it gradually tapers to 6mm. at its tip. The most dependant part bears a triangular facet inferiorly for articulation with the transverse process of the atlas.

atlas. The process projects to a lower level than either the tip of the mastoids or the condylar surfaces. The occipital condyle on the same side as the process has a markedly convex surface while the surface of the left condyle is greatly flattened,--its surface approx-imating a plane.

The third case I alluded to was that of a North American Indian skull, where the lower reaches of the process were worn off probably by attrition. Judging from the broad base of attachment (10mm. transversely and 8mm. antero-posteriorly) and the extensive area of cancellous bone exposed at a level 7mm. below the occipital bone, the process when present in its entire-ty probably reached the transverse process of the atlas.

Corner found a faceted paramastoid once in a series of 149 skulls.

(2) Paramastoid as a Non-faceted Process.-

In the skull of a French thief a paramastoid is pres-ent on the left side projecting for 7mm. but bears no facet. In a Chinese skull H.T. 165 the paramas-toids are present as conical projections on both sides; the right process being the more prominent and extends downwards for 8mm. from the under surface of the ex-occipital.

In the crania of all the races examined taken collec-

collectively the process was present in 5.6%. In 4% it was unilateral and in 1.6% it was in evidence on both sides.

Testut termed the process the paramastoid from a relation he described as existing between it and the mastoid process. Hyrtl has since refuted this assertion. Dr R. H. Charles' results point to this process being very commonly met with in skulls of the Panjab tribe. The custom amongst these people of carrying loads on their heads is taken by him to account for the paramastoid, as well as the "condylus tertius" of Meckel and the "processus papillares" of Halbertsma. He states that this process is prominent when the occipito-lateralis muscle and the occipito-atloid ligament are well developed. The increased stress on these structures due to the weight on the head, he adds, favouring the increased size of these two structures.

The paramastoid process in man is homologous with that of the lower animals. This process in herbivora and sloths, even when very young, is well marked. It is also seen as a prominent process in races of man who, in common with the herbivora and sloths, are not accustomed to carry loads on the head.

I found this process to vary in different races. I have compiled the following percentages from the

the crania examined in which the process was present. Sandwich Islanders 13.5%, Burmese 12.5%, Australian 10%. With lower percentages follow Irish 4%, Scotch 3.5%, French 2.5%. It was absent in the Greek, Swiss, Russian and Egyptian crania. It is not with-out interest to note that all the faceted paramastoids in my series were in crania of primitive man. This led me to refer to the faceted processes described in other collections. I find that in the two in-stances Dr J. Barnard Davis describes, one is a Snadwich Islander, and the other an Nahugan from the Polynesian Archipelago. The skull in St Thomas's Hospital museum is that of a North American Indian. No.747 in the Nor. Hum. Ost. Ser. is an aboriginal Philippine Islander. In every skull with a faceted process that I have been able to trace it invariably turns out to be that of some aboriginal type of man. On referring to the percentages that I found in differ-ent races it is seen at a glance that the paramastoid is of far greater frequency in the "lower" races. This coupled with the fact that (as far as I have been able to ascertain) the faceted processes are exclusively found in primitive man, is of very special interest as throwing light on the relation of man to forms a little lower in the scale of life where the paramastoid is a constant feature.

Professor Sir William Turner has drawn my

my attention to an occipital bone presented by him to the Anatomical Museum of the University of Edinburgh. The paramastoid projects downwards for an inch and is faceted anteriorly near its tip.
No history is attached to this bone and thus it can have no bearing on my conclusions.

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PLATE XVI.-

North American Indian. British Columbian Coast.

(1) Flattening over occipital region.

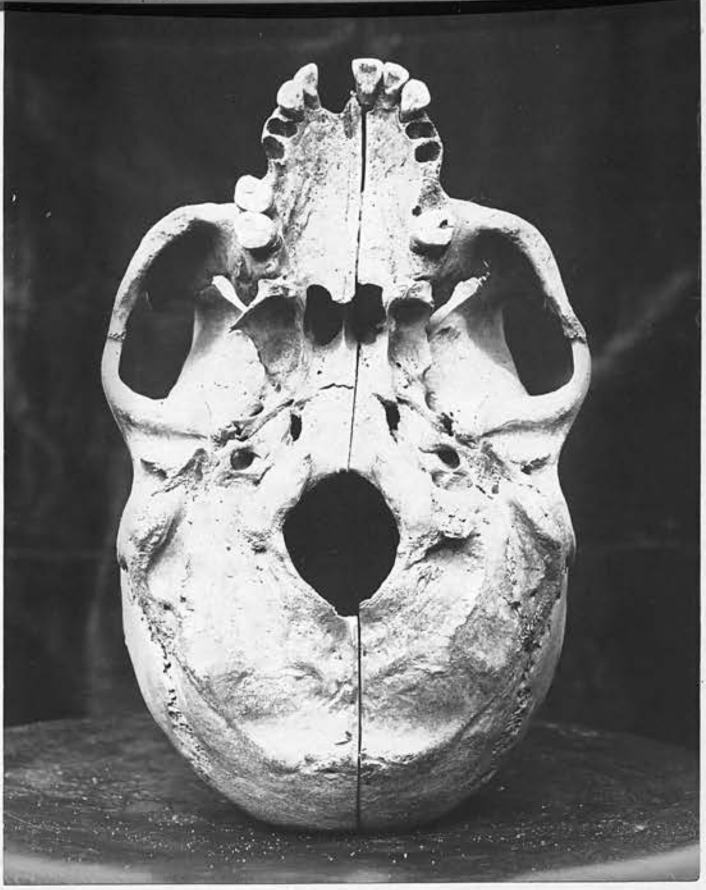
(2) Very distinct paracondylar process, seen as a ledge fringing the anterior and external border of the occipital condyles.

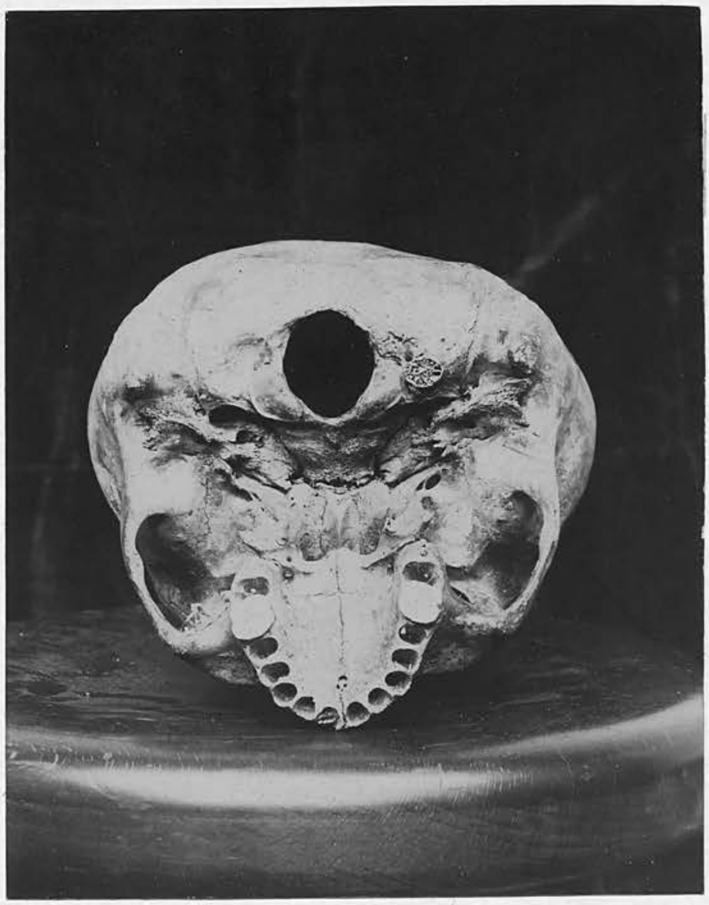
(3) Paramastoid process on right side.
Its lowest reaches have been removed by attrition, and a cancellous surface is left measuring 10mm. in transverse diameter and 8mm. antero-posteriorly.

PLATE XVII.

Sandwich Islander. Oahu D.

Prominent paramastoid projecting 8.5mm. from the inferior surface of the left jugal process.
It bears an articular facet on its outer aspect terminally.





PTERYGOSPINOUS FORAMEN.

This foramen is normally present in various mammals with complete bony boundaries. The lower boundary of the foramen in man is usually completed by the pterygospinous ligament of Civinini. This ligament is attached in front to the posterior margin of the external pterygoid plate and the junction of its upper and middle thirds; posteriorly it is attach -ed to the spine of the great wing of the sphenoid. Several observers in the various schools of Anatomy in the United Kingdom have recorded their results as to the frequency of the ossification of this ligament in the Journal of Anatomy and Physiology, Vol.XXVII. p.66. The ligament was present in 141 out of 218 skulls. It was partially ossified in 21 skulls and in 6 specimens the inferior border consisted of a bony bar extending uninterruptedly across from the spine of the sphenoid to the hinder border of the external pterygoid plate. This gives a frequency slightly under 3% in this series.

In 13 skulls the ligament was ill defined and was described as membranous, while in 30 skulls no trace of the ligament was found.

Brodie of Middlesex Hospital and Bailey of St Battholomew's Hospital describe several skulls where a muscular band exists having similar attachments to the

the pterygospinous ligament. These observers are not of opinion that this represents the ligament in the muscular form as in most of the cases a ligament was present in addition to the muscle.

Judging from these observations on the recent subject the lower boundary of this foramen may be either bony, muscular, fibrous, membranous or wanting.

Dr Yule Mackay of Glasgow describes another ligament in this region. It is attached in front to the posterior border of the external pterygoid plate about midway between the point of attachment of the pterygo-spinous ligament and the upper extremity of the plate. Posteriorly it is attached to the under surface of the great wing of the sphenoid immediately antero-externally to the foramen spinosum. He terms this the pterygosphenoidal ligament. It was present as a fibrous band in 5 out of 15 recent subjects where he looked for it. In two it was strongly marked and partly ossified. In an Australian skull from the Monro iii^ius collection I found a bony bar present on both sides closing in a foramen. This bar coincided in its attachments with the pterygosphenoidal ligament.

It is interesting to note the relation of the inferior maxillary nerve to the pterygospinous ligament. In 92 out of the 104 cases the nerve was superficial to the ligament, and inferior to the ligament in 12

12 instances. In four skulls am intermediate condition was present, the lingual nerve was inferior to the ligament while the rest of the nerve was above it. In one case where the ligament was ossified a bridge of bone separated the fibres of the lingual nerve into two bundles--one superior and one deep to the bony bar. The ligament described by Dr Mackay lies between the two main divisions of the inferior maxillary nerve, and is external to the middle menin-geal artery.

In a North American skull H.T. 573 both external pterygoid plates were large and a pterygospinous foramen was completed on both sides. A second foramen is nearly completed on the left side.

In a Russian skull No.2 two pterygospinous foramina are present on the right side and a foramen is within 1mm. of being completed on the left side. In a Lowland Scotch skull I found three pterygospinous foramina present on the right side. I describe these supernumerary pterygospinous foramina as I do not find any instances recorded.

I found that the presence of a pterygospinous foramen was in the great majority of skulls associated with the presence of a large external pterygoid plate. In some skulls this plate was small and its posterior border concave; whilst in others it projected backwards over 2.5 centimètres.

centimètres. The plate was distinctly enlarged in 13% of all the crania examined. In the skulls I examined it was not characteristic of any race.
In the 109 skulls of Gorilla Savagei that Duckworth examined the external pterygoid plate was usually small and not markedly everted.
Hyrtl in 1846 described the pterygospinous foramen as being very rare. He regarded it as an ossification of the pterygospinous ligament of Civinini.
In the observations on the recent subject already referred to it is not stated whether a pterygospinous ligament was associated with the presence of the pterygospinous foramen.
Professor Sir William Turner observed three skulls possessing a pterygospinous foramen amongst the 143 crania collected by the "Challenger."
Barnard Davis noticed the condition in 1 out of 25 Javan, and in 1 out of 11 Fatuhivan skulls. Van der Hoeven found two out of nine Caroline Island crania possessing this variation.
Roth has written a monograph on the pterygospinous foramen. The material on which he made his observa-tions consisted of 207 crania. He found this condi-tion present in 4.8% of the skulls. It is a remarkable coincidence that in my more extensive series of 613 skulls I found a pterygospinous foramen complete in 4.9%.

4.9%.

Roth gives very high percentages where the foramen was partial or complete in the primitive races. Australians 50%, Africans 30.6% and American Indians 20%. Professor Sir William Turner in his monograph on the Challenger crania very appropriately remarks that the number of exotic skulls that Roth examined was far too small for deducing any sound inferences. My results amply confirm this. In the series of 74 Australian crania that I examined I found a complete foramen present in three skulls.

The African skulls gave a frequency of 9% and the American Indian crania 6%. It is thus seen that the percentages that my observations yielded from the examination of these races differ widely from those given by Roth.

The pterygospinous foramen with complete bony walls was most frequently present in some of the European crania I examined:- Greek 12%, Irish 10%.

Roth refers to the pterygospinous foramen as characteristic of the "lower" races. The results of my examination of European and exotic crania directly traverse Roth's conclusions.

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PLATE XVIII.-

Esquimaux. H.T. 248.

External pterygoid plates exceedingly large on both sides measuring over two and a half centimetres antero-posteriorly.

Large pterygospinous foramen on right side of skull.

PLATE XIX.-

Irish. H.T. 10.

(1) Large external pterygoid plate and pterygo-spinous foramen on left side.

(2) Right occipital condyle presents two facets one looking forwards, downwards and outwards; the other looking backwards, downwards and outwards.

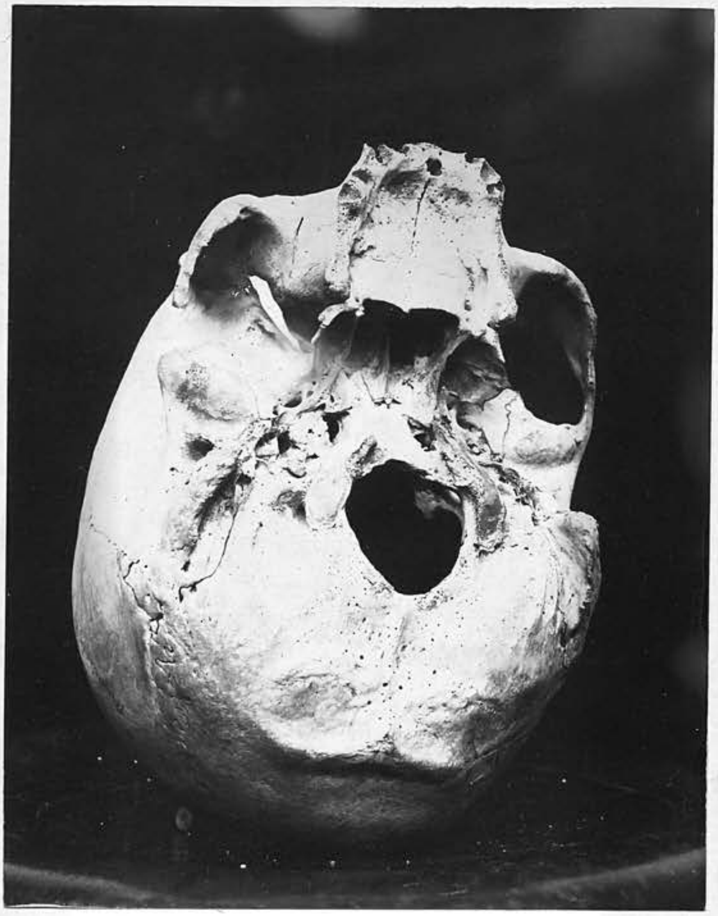

PLATE XX.-

Russian. No.3.

Large external pterygoid plate. Pterygospinous foramen present on the left side of the skull.

PLATE XXI.-

North American Indian. H.T. 573.

Both external pterygoid plates very large. On the left side the plate extends so far backwards as to be in the same vertical plane as the foramen spinosum. It is 26mm. in anteroposterior diameter.
There is a pterygospinous foramen present on both sides. On the left side a second foramen is nearly completed.

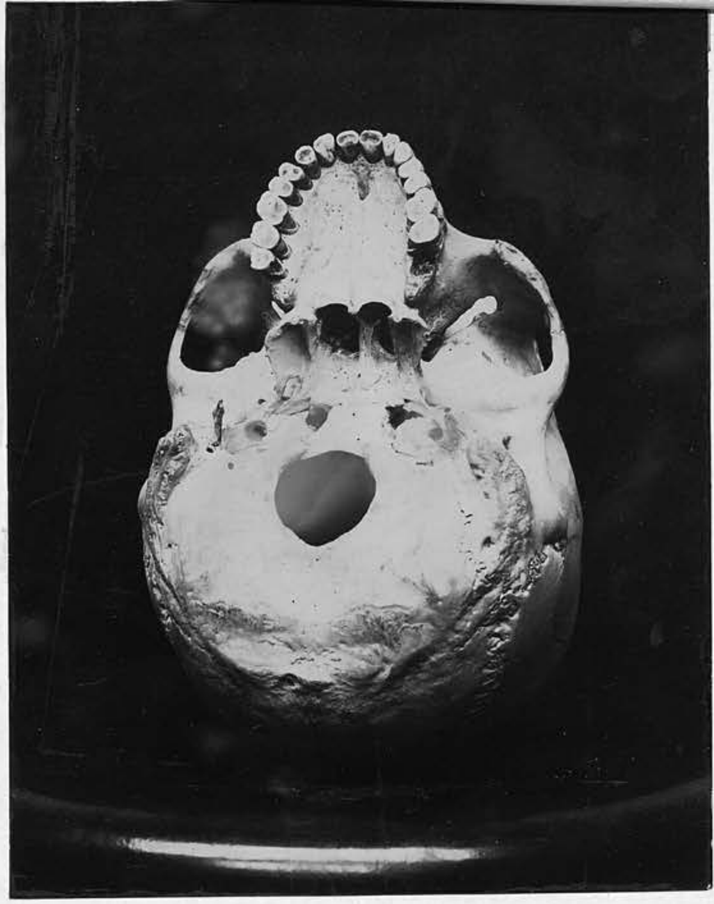

PLATE XXII.-

Moriori Skull.

(1) Pterygospinous foramen on left side of skull.

(2) Indication of a boat-shaped palate.